REPORT
432-02
NOVEMBER
2017

Risk management in geophysical operations

Supplement to Report 432

Acknowledgements

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Revision history

VERSION	DATE	AMENDMENTS
1.0	November 2017	First release

Contents

Risk Management

General

IOGP Report 510 lists Risk Management as one of the four fundamentals of a successful HSE-MS. Risk management must be integrated throughout the management system. It should be present in the cycle of design, development, implementation, maintenance and continuous improvement. The geophysical industry has static hazards and risks that are inherent to its assets and operational activities. While most of the risk cannot be completely eliminated, it needs to be managed and controlled to a tolerable level of residual risk.

Everyone should be aware of the hazards and risks present in their workplace and those of their colleagues around them and, importantly, the control measures that need to be applied to render risk tolerable. Risk needs to be assessed before the start of a project and risk control measures selected and assessed. This must be followed up by training and communication to those who may be affected by the task to be performed. Risk Management (awareness, identification, assessment and control) is further maintained through a number of processes such as hazard reporting, Job Safety Analysis (JSA) and a stop work culture (using tools such as stop and step back, or last minute risk assessments) in case of doubt or new or unexpected situations. Where exceptions or changes need to be made these should be controlled by a Management of Change (MoC) process or a new toolbox meeting, which includes a risk assessment. Certain high-risk activities must be subject to a Permit to Work (PTW) system, which again includes a risk assessment.

The concept of Risk and the Risk Assessment Matrix (RAM)

In this document, we will refer to a Hazard as anything which can cause harm or potential harm. Harm could be caused to people, to the environment, to the assets or equipment being used, or to the reputation of the company or the industry. Risk is the product of the potential consequence and the probability of an event occurring.

To rank the level of Risk the recommended tool is the Risk Assessment Matrix (see Table 1), which combines a Consequence scale (sometimes 'Severity' is used) and a Probability scale (sometimes 'Likelihood' is used). Industry uses a historical based probability scale, by determining what has happened and how often it has occurred. It is hoped that the known history will provide a reasonable approximation of the true Probability. This is acceptable for activities and tasks conducted frequently.

The Risk Assessment Matrix (RAM) for geophysical operations

An example RAM for the geophysical industry is shown in Table 1. Companies may adjust some definitions to match their size and activities.

Table 1: Risk Assessment Matrix (RAM) for Geophysical Operations

				Probability	Probability				
				Scale Levels	A	B	C	D	E
				General	Very unlikely	Unlikely	Possible	Likely	Very Likely
Company logo goes here				Historical	Never heard of in the industry operations	Has occurred in industry operations	Has occurred in geophysical operations or similar E&P operations	Happens about yearly in similar geophysical operations worldwide	Happens about monthly in similar geophysical operations worldwide
				Descriptive	A freak combination of factors would be required for an incident to result	A rare combination of factors would be required for an incident to result	Could happen when additional factors are present but otherwise unlikely to occur	Not certain to happen but an additional factor may result in an accident	Almost inevitable that an incident would result
Consequences					Probability				
People	Environment	Assets	Reputation	Severity	A	B	C	D	E
No health effect/injury/ illness	No effect	No damage	No impact	0					
Slight health effect/injury/ ilness	Slight effect	Slight damage	Slight impact	1					
Minor health effect/injury/ ilness	Minor effect	Minor damage	Limited impact	2					
Major health effect/injury/ illness	Local effect	Local damage	Considerable impact	3					
Single fatality / permanent total disability	Major effect	Major damage	Major national impact	4					
Multiple fatalities	Massive effect	Extensive damage	Major international impact	5					

Risk classification and management response	
WHITE	Maintain existing risk control measures
YELLOW	Control at workplace level and manage for continuous improvement
ORANGE	Requires constant management attention and incorporation of risk reduction measures
RED	Very substantial risk reduction measures and seriously consider alternatives

The probability scale has three levels:

- 'General', with simple descriptors ranging from Very Unlikely to Very Likely
- 'Historical', should be used if sufficient historic data are available, considering the industry or comparable activities in other industries
- 'Descriptive', which can be used in case there would be insufficient data available, for example with new technology.

For example, Column C considers the probability of occurring on Geophysical and similar Exploration and Production (E&P) operations. Columns D and E take into consideration how often things tend to happen in similar Geophysical operations worldwide.

Companies may construct more detailed severity scales and descriptions related to their Risk Exposure.

The RAM can be used to assess the qualitative risk of planned future activities as well as to calculate the potential outcome of actual incidents.

Establishing the consequence or potential consequence is usually straightforward. However, establishing the probability may be more difficult. For events that have a low probability of occurrence but a high severity outcome, the *IAGC Aide Memoir for Geophysical Risk Assessors* provides historical geophysical industry.

For new tasks or rarely performed ones, there may not be sufficient historical data. For this, the descriptive scale shown in Table 1 can be used. A new activity should not be considered zero risk, just because there is no historical record.

Risk Assessment and Control

The process of Risk Assessment and Control consists of a number of steps:

1) Establish the activity, the tasks and the context
2) Identify the hazards
3) Assess the potential consequences
4) Evaluate the probability and plot the risk score
5) Manage the risk with control measures
6) Determine the level of residual risk and confirm tolerability
7) Assess the tolerability of potential escalating factors
8) Risk mitigation and recovery measures.

Step one: Establish the activity, the tasks and the context

The risk produced by a hazard depends on the task and the context in which the hazard exists. For example, water may be considered a hazard, but in the context of an office environment it may produce asset damage, but probably will not cause drowning. Water, in the context of small boat operations, will produce a different set of potential outcomes which may present more serious consequences, which will change the risk tolerability. The task and context must be clearly defined for each hazard.

Step two: Identify the hazards

Within the defined context, the relevant hazards should be identified and documented in a hazard register. This requires knowledge of the task and is usually done by a team of experienced people.

Steps three: Assess potential consequences

For an identified hazard, the potential consequences are determined and documented in the risk register. A hazard can have a consequence in several categories (e.g. People, Environment, Assets, Reputation – PEAR), and each one should assessed independently.

Steps four: Evaluate the probability and plot the risk score

For each identified hazard and consequence, the probability of it materializing is assessed and documented in the risk register.

From the various consequences that may be assessed for each hazard, the highest risk is documented in the risk register and may be plotted on the RAM. This is the inherent level of risk prior to control measures being applied (i.e. It is assumed that IOGP 432 Table 1 and 2 are already applied).

Users should be aware that the historical based RAM scale level has limitations where the geophysical industry has few exposure hours. For example, chainsaw tree felling has caused many fatal accidents in geophysical operations and technically its risk would plot in cell D-4, the same score as vehicle incidents. However, if the industry would accumulate as many hours in chainsaw tree felling as it does in vehicle usage; this risk would shift to E-4, with fatalities monthly.

Step five: Manage the risk with control measures

Establish the control measures which must be used to reduce the risk to tolerable and As Low As Reasonably Practicable (ALARP) level. Controls should be selected using the hierarchy of controls, in order of decreasing effectiveness:

- by appropriate design (e.g. equipment, the survey, etc.).
- eliminate the hazard if safe to do so
- substitute with a lower risk situation
- engineering controls to manage the hazard
- safe working practices and procedures combined with training
- administrative controls such as PTW, authorized personnel only, etc.
- Personal Protective Equipment (PPE). This must always be the last control system after all others have been put in place.

The design phase is the most effective time to eliminate potential hazards. Often a combination of these control measures will need to be used. Risk reassessment should be conducted following application of control measures to evaluate unintended consequences.

Step six: Determine the level of residual risk and confirm tolerability

With the selected control measures in place assess the residual risks and ensure that they are tolerable and ALARP. Obtain signed approval and a MOC if the residual risk falls outside the tolerable region and no further practical measures are feasible.

ALARP is usually defined as the level beyond which further risk reduction would require disproportionate cost, time or effort. The organization should define criteria linking the level of risk acceptance to a management level for approval. The higher the residual risk level, the more senior the risk acceptor should be.

When assessing the residual risk, measures from the top of the hierarchy of controls may change the task. This can potentially reduce both the consequence and the probability. Within the context in which the hazard exists, elimination of the task will change both the consequence and the probability.

It should be noted that controls from the lower end of the hierarchy such as administrative controls, most often do not alter the potential consequence, only the probability. For example, seatbelts save lives, but even with seatbelts the result of a high speed vehicle incident can be fatal.

Step seven: Assess the tolerability of potential escalating factors

Escalating factors, when combined with certain tasks, may increase the probability of an incident occurring or its consequences. Examples of escalating factors are:

- Working alone
- Working during darkness
- Poor visibility
- Fatigue
- Weather beyond certain limits
- Sea State beyond certain limits.

For the tasks under consideration, the tolerability of escalating factors needs to be identified and assessed. Escalating factors can change over the time the task is being conducted, e.g. weather, fatigue. These factors must be monitored while the tasks are performed. A re-assessment of the risks should be performed frequently. Usually this assessment is reflected in the procedures for a task and/or a Matrix of Permitted Operations (MOPO).

Step eight: Risk mitigation and recovery measures

Organizations should be prepared to respond to a breakdown event and when an incident may have occurred. The goal of the response is to regain control of the situation and to minimize potential consequences. Emergency response plans (ERP) should be available to respond to incidents.

Timing of Risk Assessment and Control

Risk assessment should be done at all stages of a project. Before issuing a tender, the client should assess and disclose the major hazards pertaining to the project area. This assessment should be conveyed to potential tenderers in the invitation to tender.

Before a project, crew or vessel is mobilized a full risk assessment should be done, establishing a project specific risk register. This may take the form of a permanent risk assessment for intrinsic hazards (static hazards) and should also include project and dynamic hazards.

The significant risks identified and the related control and mitigation measures should be discussed with the crew before project start up.

The Project Risk Assessment should be reviewed and updated on a regular basis (e.g. when incidents occur or as a result of hazard reports or similar inputs). Additionally, Job Safety Analysis by a competent person should be done on a regular basis for higher risk tasks to review and improve existing procedures. Risk assessments should be as part of the Permit to Work (PTW) process and Management of Change (MOC) and for non-routine operations. All Risk assessments should be documented and understood by the personnel involved.

Recovery measures and ERPs need to be tested at the start of a project and regularly throughout the project life cycle.

Risk Verification in Geophysical Operations

A risk verification process should be designed in order to drive continuous improvement in HSE performance and should be conducted throughout the life of the project. This will help to ensure that control measures are continually implemented.

The risk verification process consists of regularly reviewing the project risk register, prioritizing the risks, and verifying that risk control measures are in place and functioning as intended, or need to be adjusted. A risk verification schedule and targets should be developed prior to Mobilization.

Field visits, inspections and conversations with the workforce at the task site are the most appropriate ways to verify that the risk controls are functioning as intended. The basic four steps are:

1) **Preparation**: The Preparation step is a critical part of the process. Risk verifications should be conducted by a pair of verifiers (observers), ideally one Client Representative and one Contractor Department Head or HSE Advisor. The expectation on seismic crews is that Party Managers, Department Heads, marine crew Masters and Officers and Client Representatives and staff will conduct risk verifications on a regular basis.

   During this stage the observers should prepare by making use of the project risk register and associated procedures for the specifically identified task. The observers will review the risk register and task procedure to identify the risk controls that pertain especially to the task that they plan to observe. They will verify that these control measures are understood and functioning as intended.

2) **Observation**: Prior to interrupting the employees performing the task, the observers look for indicators that there may be something more to the task than described in the procedure. The observers make note of any positive practices and any actions or conditions which may be of concern.

3) **Conversation**: A debrief with the employees should be held and the observers should state why they are present. Observers should commence the conversation with the positive behaviors observed. Conversation with the employees should then focus on the task procedure, to determine if it is useful and whether the employees can offer any improvements to the existing procedure. Then the conversation can proceed to the risk control and their effectiveness. The most effective conversation will be when there are follow-on questions about control measures to gain further understanding from the employees about how well the control measures are working.

4) **Action**: Following the risk verification, the observers should meet at a suitable location to provide feedback to one another on the process. Actions resulting from the conversations should be followed up by the crew management to ensure the control measures are effective. The observers should agree on who has the action, and how it will be completed. Actions are initiated through use of an action point register. Another aspect of the action step is to follow through within some days with the employees to see that control measures are still in place.

Recognition and Interventions

The risk verification process will identify the presence or absence of various control measures according to the hierarchy of controls. It is important for supervisors to recognize and reinforce positive behaviors through verbal random HSE safety award presentations.

Where 'of concern' acts and conditions are observed, and risk control measures are not being implemented, intervention should be made. Intervention or a change in process should be handled formally through the employees' supervisor unless the potential for serious or life-threatening consequences exists. In this case the task should be stopped until a resolution can be found and implemented.

Interventions and actions should be reported to supervisors and client representatives and tracked through a remedial action tracker. A summary of the intervention and/or positive recognition should be reported through a risk verification report.

Reporting

Client and contractor representatives should document the risk verification through a summary report and maintain an activity log. The activity log should be distributed to the client and contractor project managers on a regular basis who should verify the standard and quality of implementation.

Project Managers should use the risk verification reports to reinforce positive implementation or to identify improvement opportunities. Individuals should be recognized for making outstanding interventions and for consistent implementation of the risk verification process.

Aide Memoir for Geophysical Risk Assessors

Introduction

As discussed above, knowledge of what has happened in the past is essential for good Risk assessment. For frequent events, such as slips trips and falls, most companies have experienced enough of such events to have good knowledge of these. However, for the less frequent, but often more serious events, one needs to know what has happened in the industry as a whole. Without this one can be victim of the "Never happened to us syndrome". To provide this information the IOGP Geophysical HSE subcommittee and the IAGC have shared information and assembled the Aide Memoir for Geophysical Risk Assessors (AM), a simple database of fatal accidents which have happened in Geophysical operations and similar industry operations ('Other'). For example, the database contains four reports on fatal crushing's by automatic water tight doors on vessels, something which has not happened on any Geophysical vessel yet, but could easily happen there too. On the basis of these events in the AM, this Risk can be classified B-4 on the RAM.

In a later stage, reports of high potential incidents (HiPo's) which could have resulted in fatalities, but fortunately did not, have also been added.

The information was assembled using the IOGP annual statistical reports and the fatal accident reports contained therein, published since 1981. Further information was provided by the members of IAGC and CAGC. In addition, other sources like IMCA and STEP Change are monitored. The database consists of a simple Excel spreadsheet containing summary descriptions of the events and where available, cross references to IAGC or other alerts containing more elaborate information. The Aide Memoir and a user manual can be found on the IAGC website. On a regular basis it is updated as and when new information becomes available.

The Aide Memoir can be used to assess what has happened in the past and to a degree how often, for the Risks with fatal or multiple fatal Severity on the risk matrix (Severities 4 and 5). Note however that the Aide Memoir by necessity is organized by accident type and not by Hazards or Risks but often this conceptual difference can be ignored.

Some events in the Aide Memoir from long ago may be ignored as since these happened, industry may have improved its performance. For example, we no longer transport people standing up in a flatbed truck, which was common practice in the seventies. Since 2008 there has been no further drowning in the industry as the essential controls (lifejacket, swim testing and prohibition of swimming) since then have been rigorously applied in the industry. Drowning (as defined for the Aide Memoir) can now have its risk downgraded from D-4 to B-4. But the memory of the many fatalities in the past still serves to highlight the importance of the controls now considered commonplace (e.g. seat belts, etc.).

Database size and population

Figure 1 below shows the full content of the database in terms of numbers of events recorded, both in geophysical operations and in similar 'Other' operations, both fatal accidents ('Actuals') and HiPo's.

Figure 2 shows the events on record for geophysical operations, split up as Land, Marine and Transition Zone (TZ).

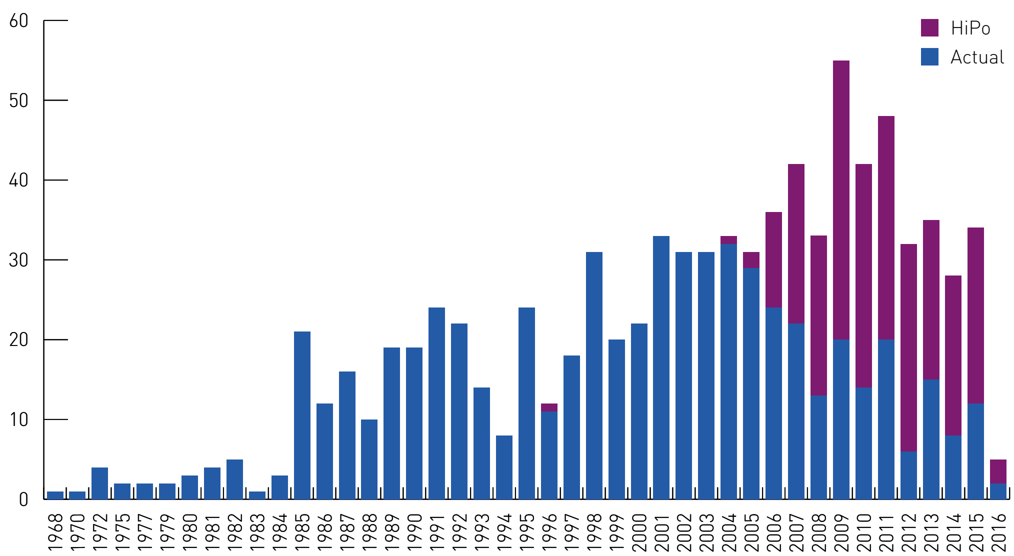

Figure 1: Full content of database by year: Geophysical and Other, Actuals and HiPo's

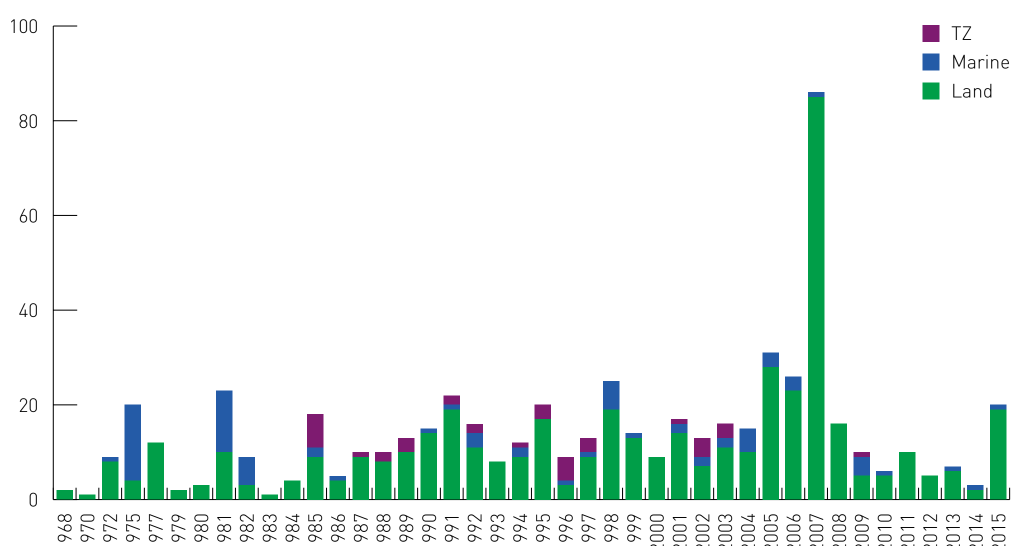

Figure 2: Geophysical, Actuals only, by year, number of fatal accidents

From these graphs it is evident that the data before 1990 is incomplete due to lack of reporting. After this date, however, the majority of events in geophysical operations by the IAGC membership are recorded. We cannot claim that the data is wholly complete, but what is on record is certified to have happened. The number of actual fatal incidents, as of May 2016, in the database for geophysical operations is, 304 from Land, 42 from Marine and 32 from TZ for a total 378.

Figure 3 shows the number of actual geophysical fatalities: Land 468, Marine 81, TZ 38, resulting in a total of 587, a very shocking and sobering number. From 2008 onward the overall trend appears to be downwards and one hopes this will continue.

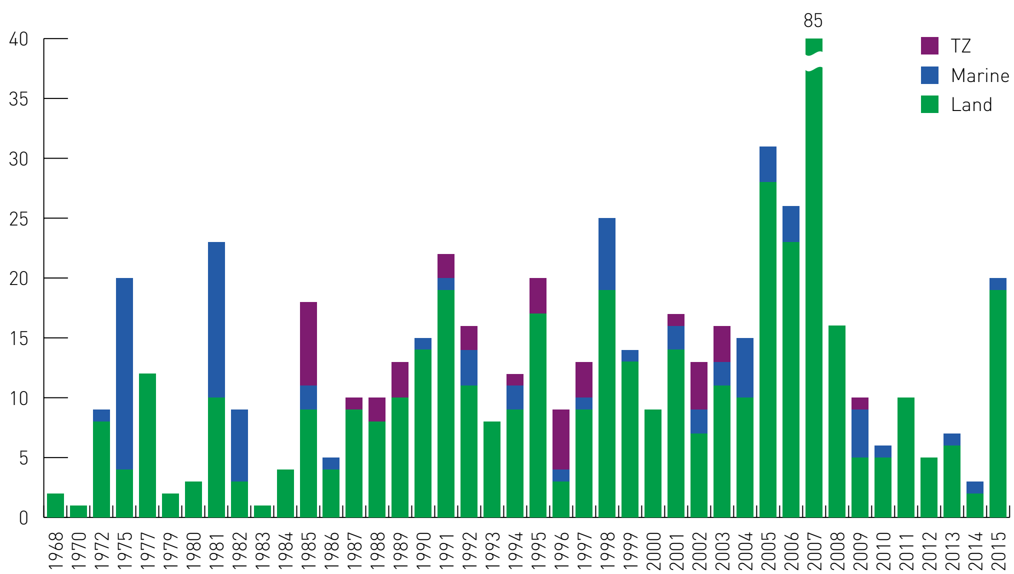

Figure 3: Geophysical, Actuals only, by year, number of actual fatalities. Peak in 2007 was due to a terrorist attack with 74 fatalities

Data Analysis: Main accident classification

Apart from the invaluable information in the individual accident or HiPo (High Potential) descriptions, classification of incidents allows some enlightening statistical analysis. The main classification developed for the Aide Memoir consists of 20 types of accidents. Figures 4 and 5 show the number of events and actual fatalities per accident class for these 20 incident types. From these graphs, it is evident what the most frequent types of fatal accidents are in geophysical operations and which ones have caused the largest numbers of fatalities.

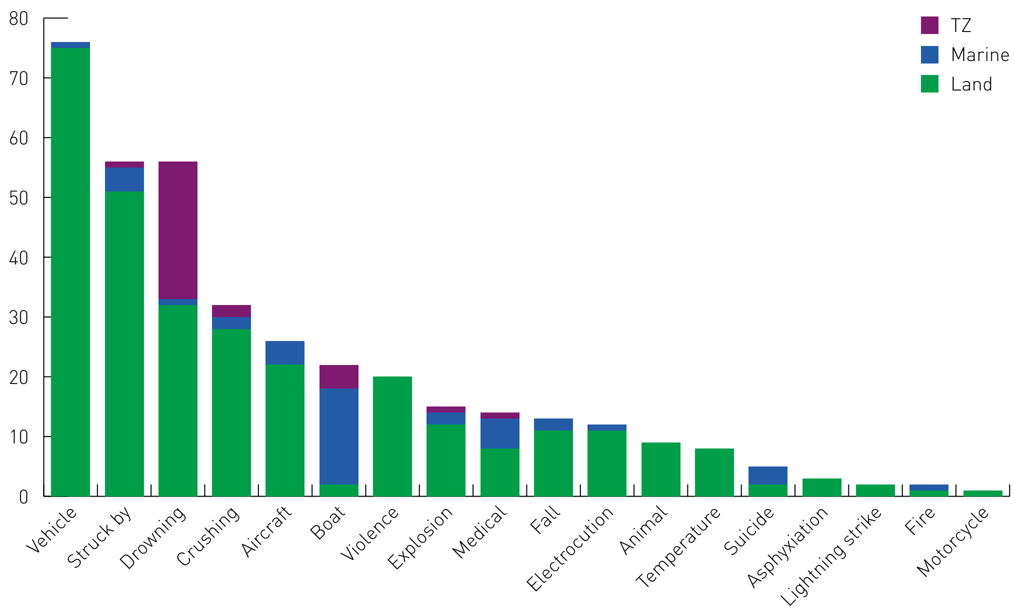

Figure 4: Geophysical, Actuals, main classification, number of incidents

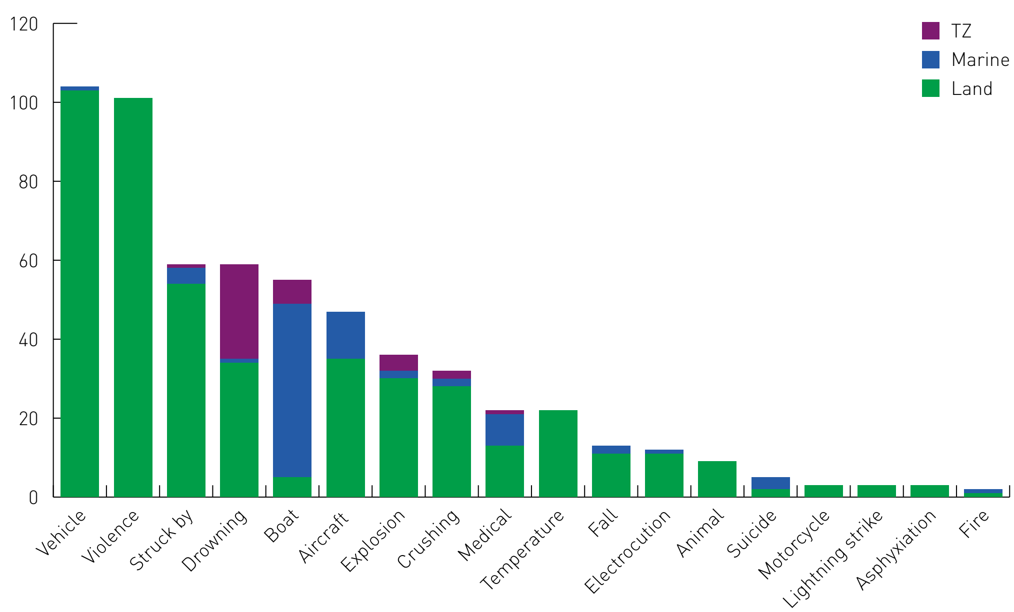

Figure 5: Geophysical, Actuals, main classification, number of fatalities

Figure 6 shows the number of actual fatalities (1078 by May 2016) for the entire database along the same accident classification. Trend is similar, but Aircraft have gained the first place which reflects the large number of multiple fatalities with helicopter crashes offshore. There have been several HiPo's of this nature in Marine geophysical operations but so far no actual major helicopter crashes. The risk for geophysical crew change flights is however similar, if not higher (moving target for landing and fewer navigation aids), than for the whole of the E&P offshore industry. Once more, we have to look broadly to arrive at a correct risk assessment.

Note, however, that in order to not make the database too large, no attempts have been made to make the data in this category complete. Events have been selected for learning value and to show that they have happened, but the information in the group 'Other' cannot be used to estimate frequencies. However, all fatal helicopter crashes on record in the IOGP reports have been included.

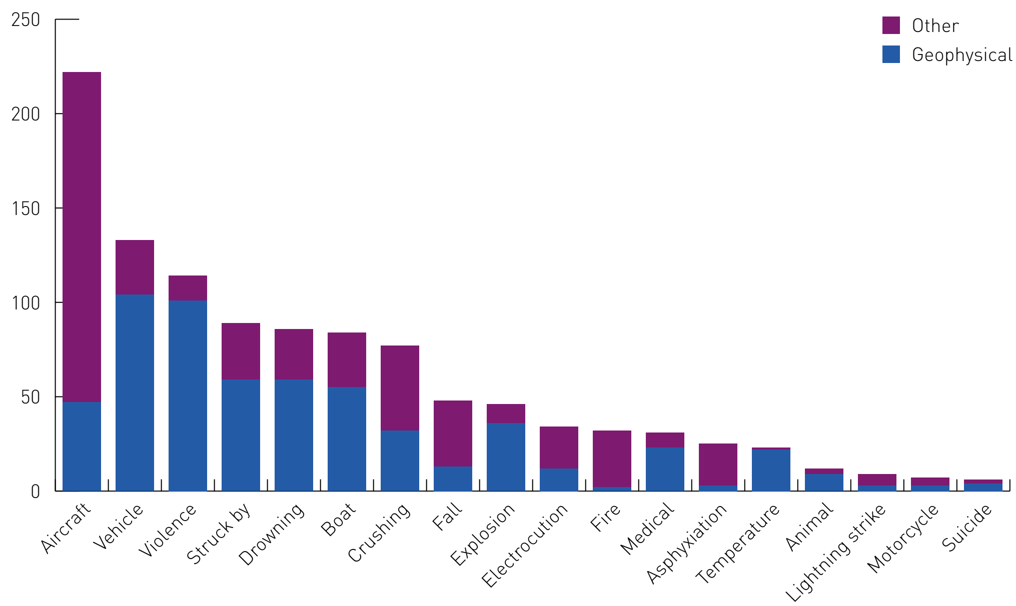

Figure 6: Geophysical and Other, number of fatalities

Violence takes second place in the number of actual fatalities in geophysical operations due to one single event in which 74 people lost their lives. Ignoring this one very serious event, it is about number 7 on the list.

While the predominance of Aircraft and Vehicle incidents was no surprise, the fact that Drowning is amongst the top five killers was to most people in the Geophysical industry when the first version of the Aide Memoir was published in 2007. The same was true for Struck by and Crushing.

As for Drowning, the industry quickly reacted by rigorously applying the necessary key controls: lifejackets, swim testing and prohibition of (recreational) swimming.

Figure 7 shows the number of drowning events per year in the geophysical industry. Although there still have been a few HiPo's, there have been no more Drownings in the geophysical industry since 2008. This can be attributed to what the industry has learned from the Aide Memoir and the simultaneous publication of the IOGP Report 355, *Watercraft and Water in Geophysical Operations*.

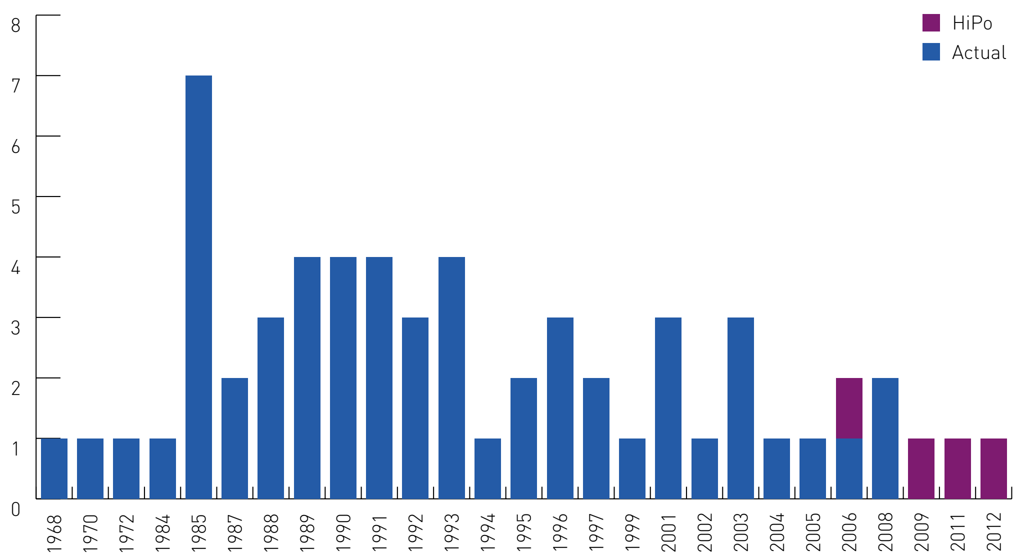

Figure 7: Drowning by year, Geophysical, Actuals and HiPo's

Note: Figure 7 does not show the years without incidents: 2013, 2014 and 2015.

RAM classification of Drowning as a whole, in the past had to be E-4 (Red), single fatality yearly or more often. Looking at the past few years since 2008, this can now be scaled down to D-4 or even B-4 (Orange).

Data Analysis: Finer accident classification

To understand the predominance of Struck By events, we had to dig deeper and develop a finer accident classification, eventually amounting to 100 sub-types.

Figure 8 shows the Geophysical Struck By events split between the 14 applicable sub types of the finer classification. Now it is evident that the main culprit is falling trees and branches, mostly related to chainsaw tree felling. Contrary to Drowning, the industry has not yet found controls to make this activity less dangerous. Falling objects in Marine were no surprise and note that IMCA and IADC report a very high incidence of such dropped objects events in drilling (DROPS), on vessels and in shipyards.

Struck by vehicle relate to vehicle and pedestrian incidents not included in the main class Vehicle, which has been reserved for incidents where drivers or passengers were injured (see below).

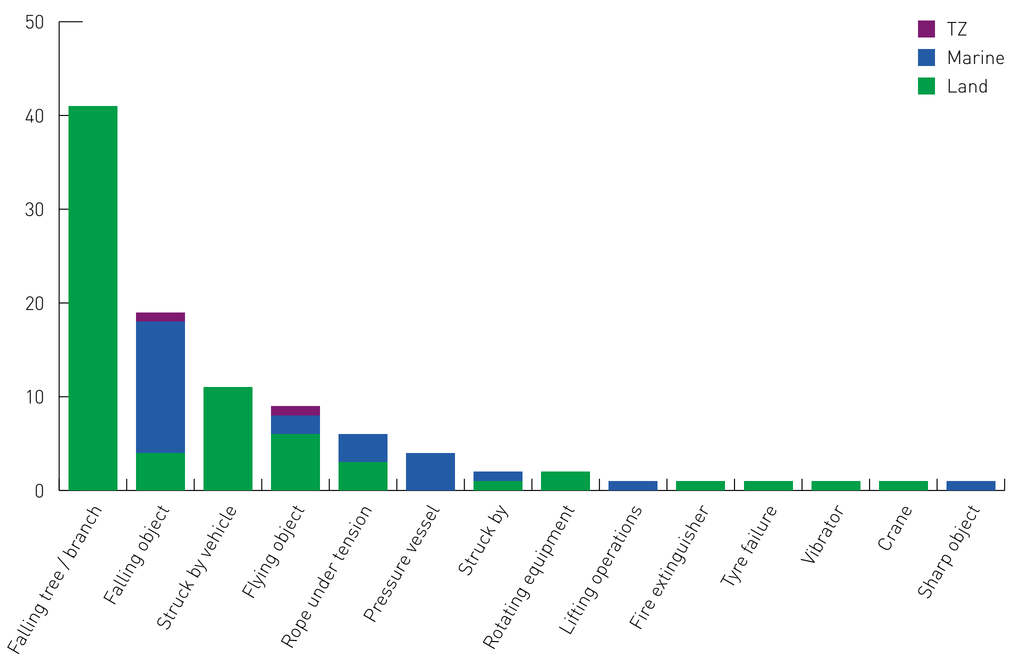

Figure 8: Struck by incidents, finer classification, Geophysical, Actuals and HiPo's.

Clearly one should not plot 'Struck By' as a single risk on the RAM, there are very different incident scenarios emanating from the finer classification. Falling tree/Branch should be classified as D-4 at least, happens yearly or more often in Geophysical operations. But given the low number of exposure hours for chainsaw tree felling, this should be upgraded to E-4. The other scenarios can be classified as C-4, Orange, have happened but not yearly.

Figure 9 shows a similar analysis of drowning events. Getting people across bodies of water ('River crossing'), falls into water from a river bank etc. and (recreational) swimming clearly are the main contributors.

One could classify these individually on lower scales of the RAM but this would be misleading as the scenarios are quite similar and the controls almost identical. Rather than splitting this up as 8 separate risks each as C-4, up to 2008 the whole of Drowning should be grouped together as a single risk E-4, Red. With the recent history without Drownings this can now be downgraded to C-4, or even B-4, both Orange.

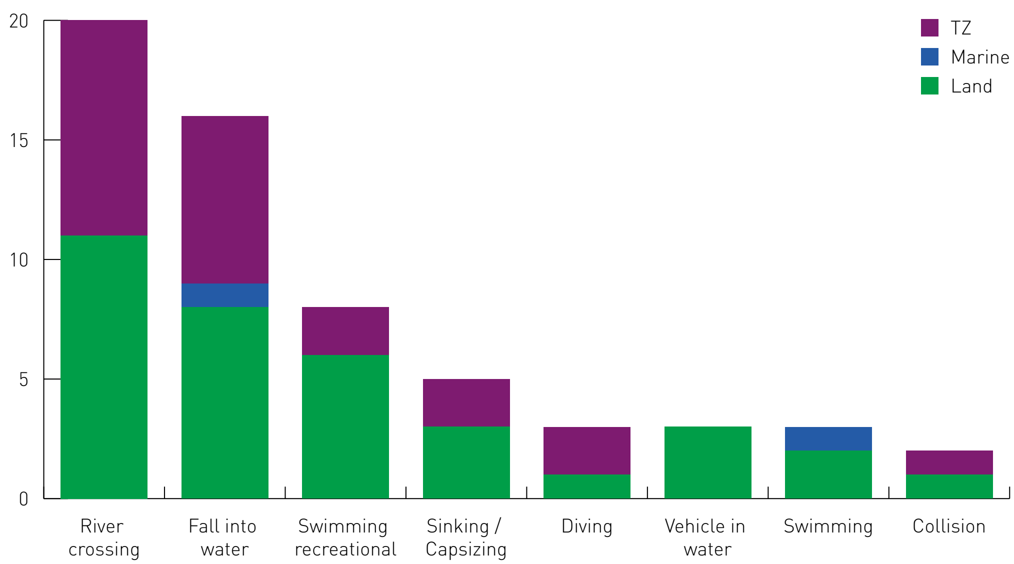

Figure 9: Drownings analyzed using the finer classification. Geophysical, Actuals and HiPo's.

Note that the main class Drowning relates to the type of events shown in Figure 9 as an operationally effective classification. As such, most of these events happened in Land and TZ (Transition Zone) operations.

Events where drowning was no doubt the actual cause of death, such as vessels sinking, Man Over Board (MOB) from large seagoing vessels, FRC (Fast Rescue Craft) and Workboat incidents are ranged under the main classification 'Boat', mostly Marine operations. Figure 10 shows the Boat incidents with their finer classification. Note that a number of offshore suicides were classified in the main class Suicide, while technically also MOB cases.

Note the numbers of falls with lifeboat (Includes FRC and Workboats).

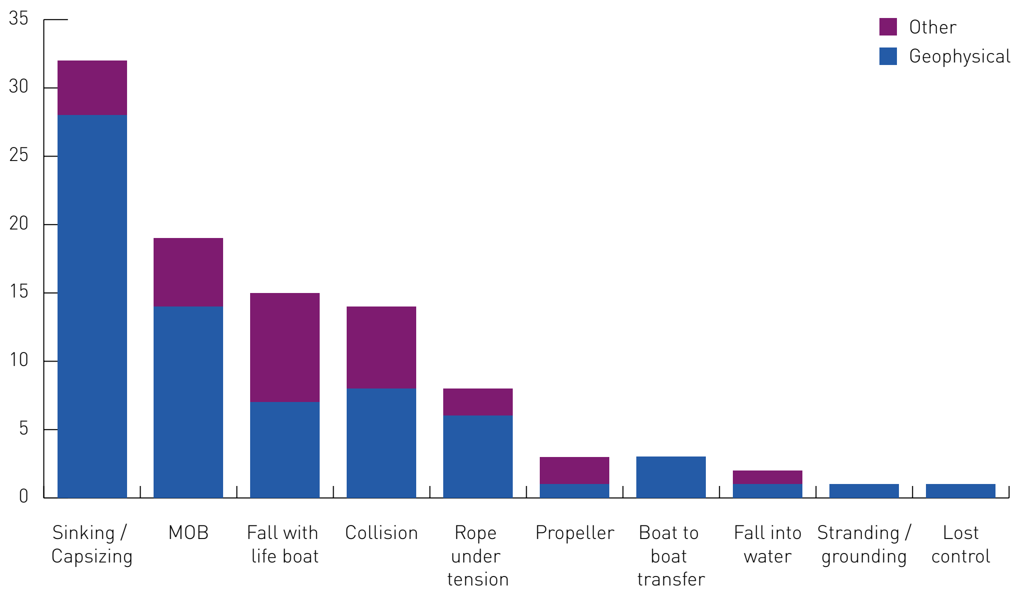

Figure 10: Boat incidents by finer classification, Geophysical and Others, Actuals and HiPo's

Sinking/Capsizing could possibly be classified as D-4 and C-5, Red, the others C-4, Orange, on the Ram.

Figure 11 shows the Crushing incidents with their finer classification. Crushed by vehicle again relates to vehicle and pedestrian events, mainly related to reversing, but also including some cases of people sleeping under vehicles which were driven away.

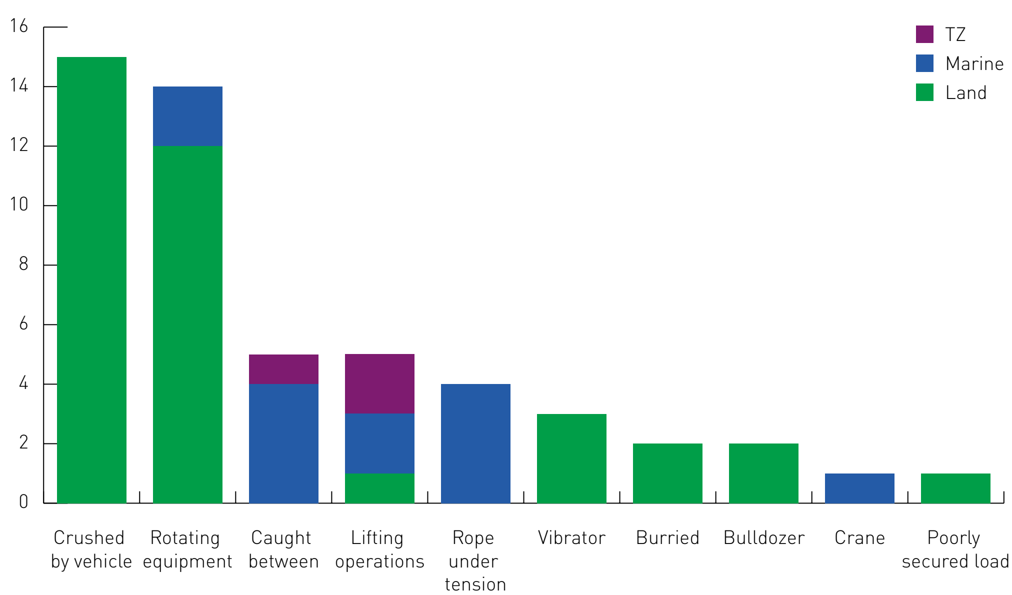

Figure 11: Crushing incidents, Geophysical: Actuals and HiPo's

Crushing by vehicle (mostly reversing) borders on D-4, Red, and Rotating equipment also. The others should be classified as C-4 or B-4, Orange, on the RAM.

Figure 12 shows all incidents involving vehicles with their finer classification. These are assembled from the main categories Vehicle, Struck By, Crushing and Motorcycle. Roll over and Collision are the most frequent events. Followed by the vehicle and pedestrian events (Struck by and Crushed by Vehicle). 'Crash' are motorcycle incidents.

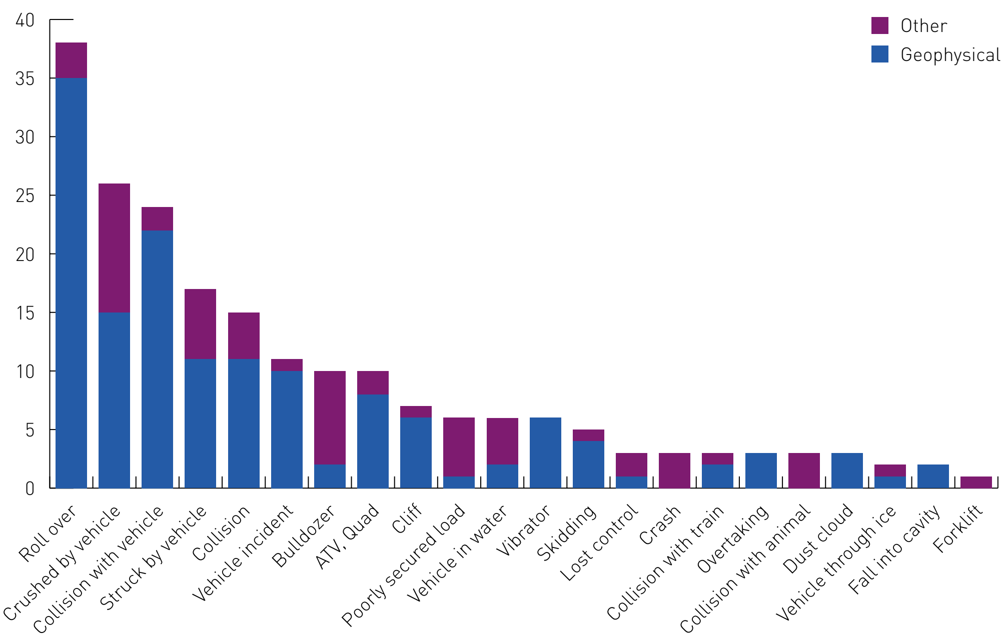

Figure 12: All incidents involving vehicles, Geophysical and Other, Actuals and HiPo's

As discussed before, for Risk Assessment it is considered best to lump most of these together as a single risk ('Vehicle in motion' or 'High Speed driving') E-4, Red, on the RAM. Some specific scenarios such as All-Terrain Vehicles (ATV)/Quad, Vehicle through Ice (B or D-4, Orange) can be addressed individually as requiring specific context and controls.

Figures 13 and 14 show the number of aircraft incidents and actual fatalities. As discussed earlier, the offshore helicopter crashes are very prominent. However, in terms of number of incidents, Land seismic helicopter usage, in particular with external loads are by far the most frequent helicopter events in Geophysical Operations, with roughly one fatal crash per year (single fatalities).

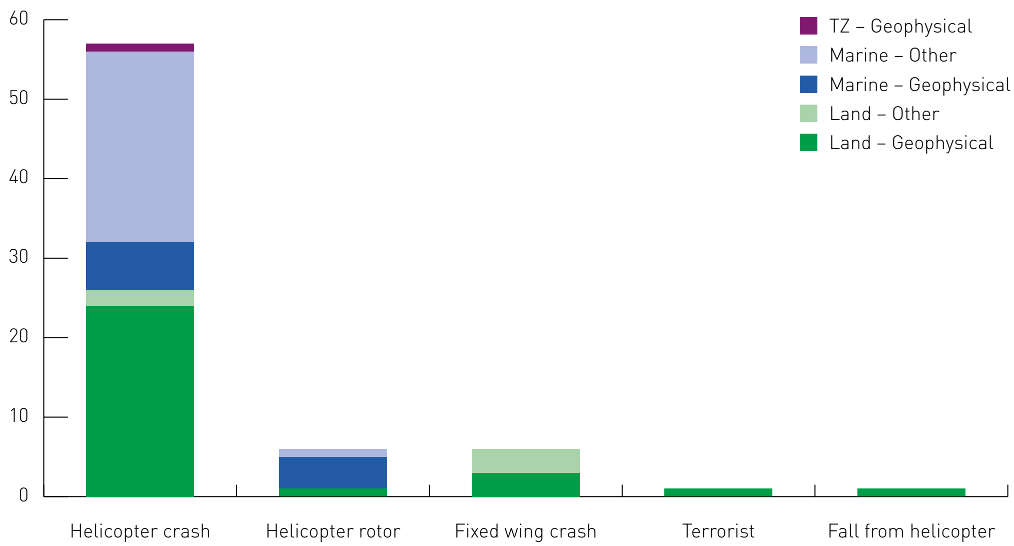

Figure 13: Aircraft accidents number of events, Geophysical and Other, Actual and HiPo's

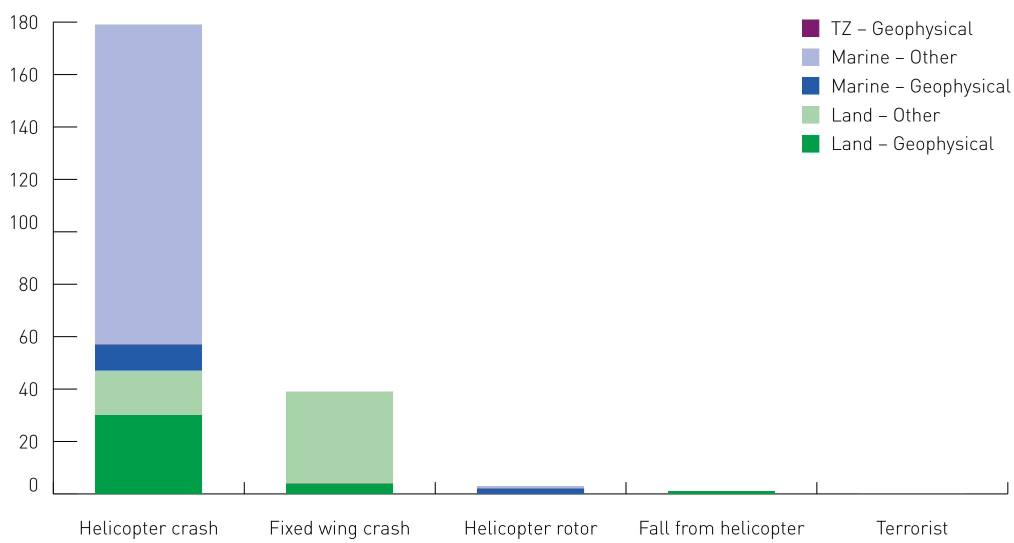

Figure 14: Aircraft accidents number of fatalities, Geophysical and Other (222)

As discussed above, it is recommended to classify Land seismic helicopter support as E-4, single fatality yearly in Geophysical operations. Offshore helicopter crew change relates to a multiple fatality scenario, Severity 5. Technically this has not happened in Geophysical operations, but it has in similar E&P operations so it should be classified at least C-5, Red.

The following Figures 15 – 23 show the finer classification for Electrocution, Violence, Animal, Asphyxiation, Explosion, Fall, Fire, Medical and Temperature. All of these rank in the B-4 or C-4, Orange, risk levels on the RAM.

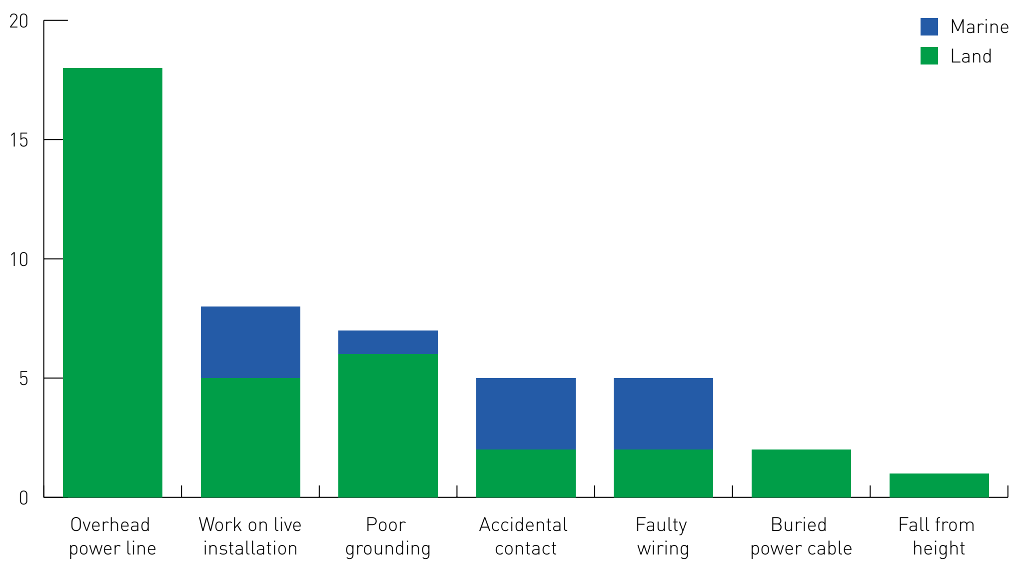

Figure 15: Electrocution, finer classification, Geophysical and Other, Actuals and HiPo's

Note the predominance of Overhead Powerlines!

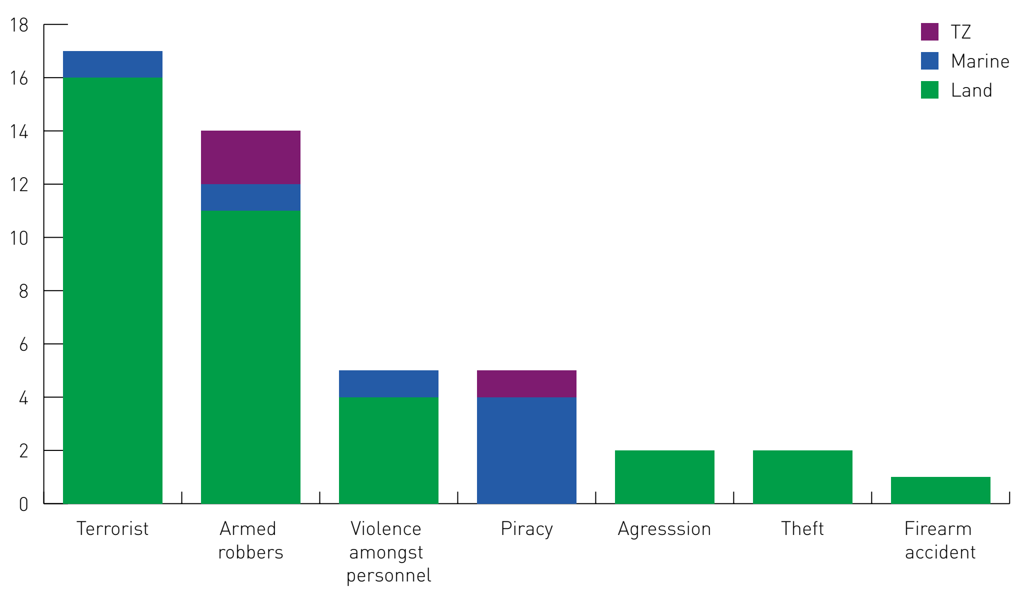

Figure 16: Violence, Geophysical and Other, Actual and HiPo's.

Note that 'Terrorist' being on the increase now borders on an E-4, yearly single fatality Red risk, in particular for the specific risk regions affected by this problem (context).

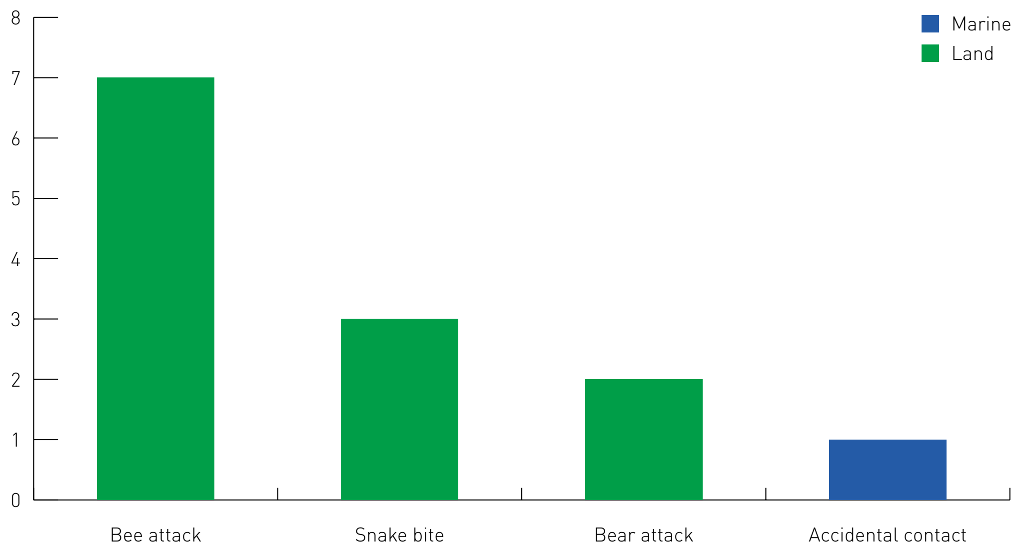

Figure 17: Animal: Geophysical and Others, Actuals and HiPo's. Accidental contact was with Irukandji Jellyfish ('Other')

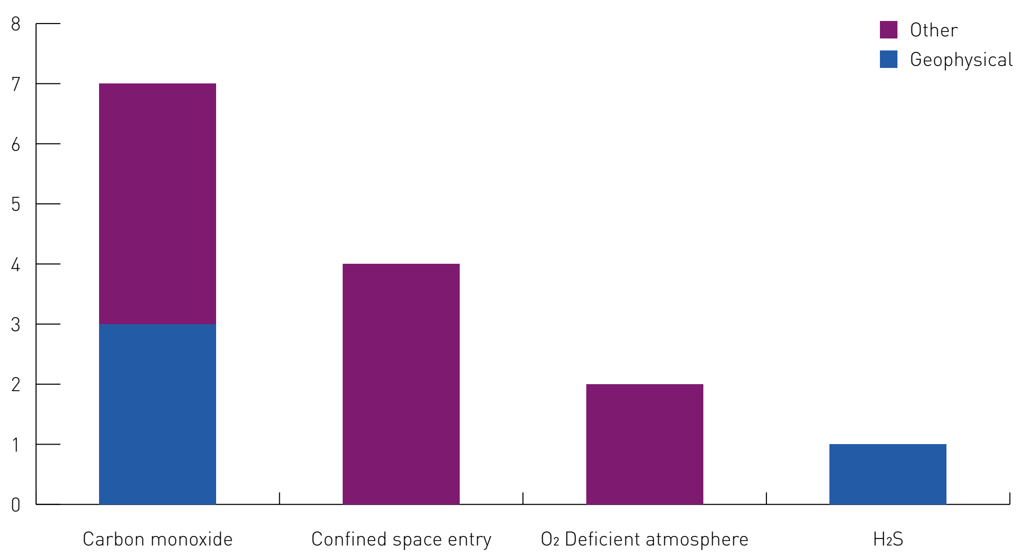

Figure 18: Asphyxiation, Geophysical and Other, Actuals and HiPo's

Note that IMCA reports a very large number of confined space entry fatalities, with about two rescuers dead for each initial entrant dying. So far, no confined space entry fatalities in Geophysics in terms of asphyxiation, but one involving a fire resulting in very serious injuries (see below). The carbon monoxide cases related to poorly installed heaters or water heaters with the exhaust gases not being evacuated to the outside of the rented buildings.

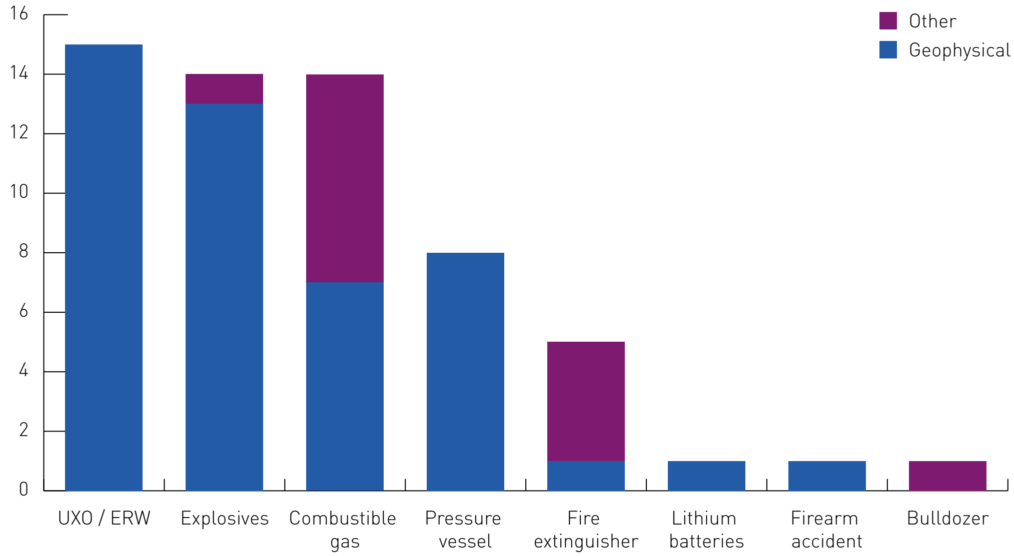

Figure 19: Explosion, Geophysical and Other, Actuals and HiPo's

Note 'Struck by' pressure vessel and fire extinguisher events have been included for completeness sake, as these can be classified both as Explosion incidents and Struck By incidents.

The bulldozer hit a gas pipeline and caused a massive explosion and fire.

UXO (Un-eXploded Ordnance) numbers do not warrant a D-4 Red classification worldwide, but in context it might be wise to classify this risk as D-4, Red, in areas with a high density UXO, especially if this includes modern plastic products that are difficult to detect.

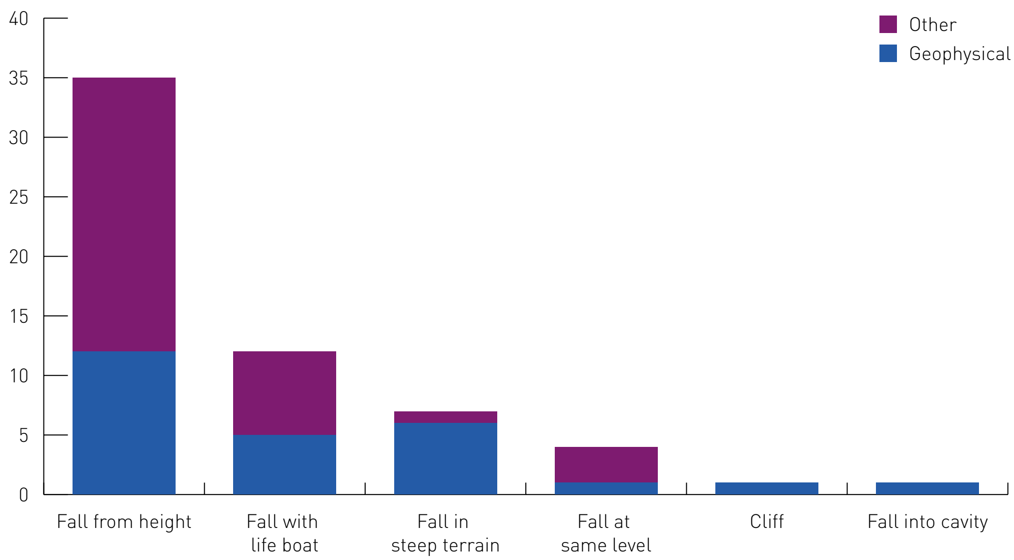

Figure 20: Fall, Geophysical and Other, Actuals and HiPo's. Note the numbers of falls with lifeboats

While normally Fall in steep terrain should be classified as C-4, single fatality "has happened in Geophysical operations", Orange, in the context of mountainous terrain one might consider classifying this risk as D-4, Red.

Note there have been fatal falls at the same level i.e. from very limited height! Falls into water have been classified as Drowning or Boat.

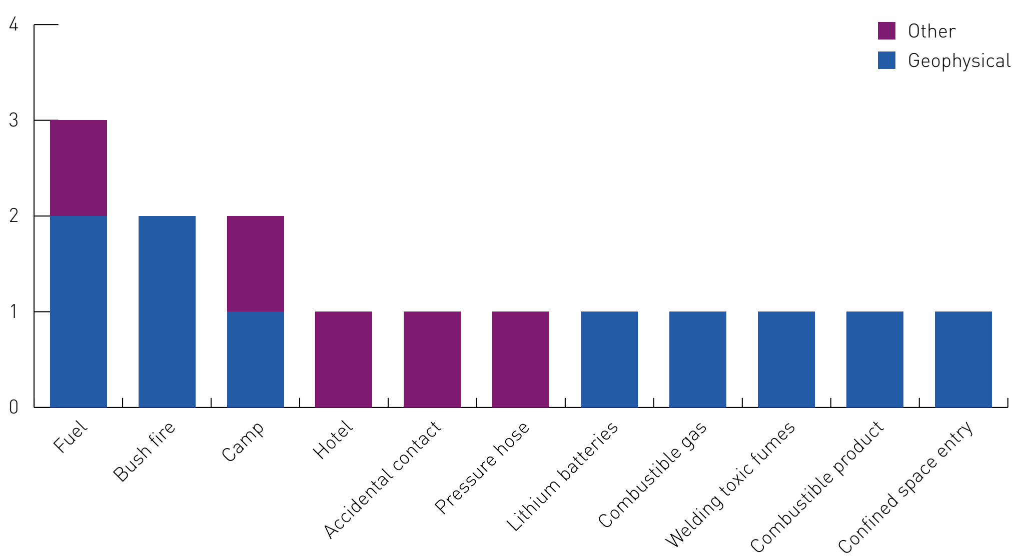

Figure 21: Fire, Geophysical and Other, Actuals and HiPo's.

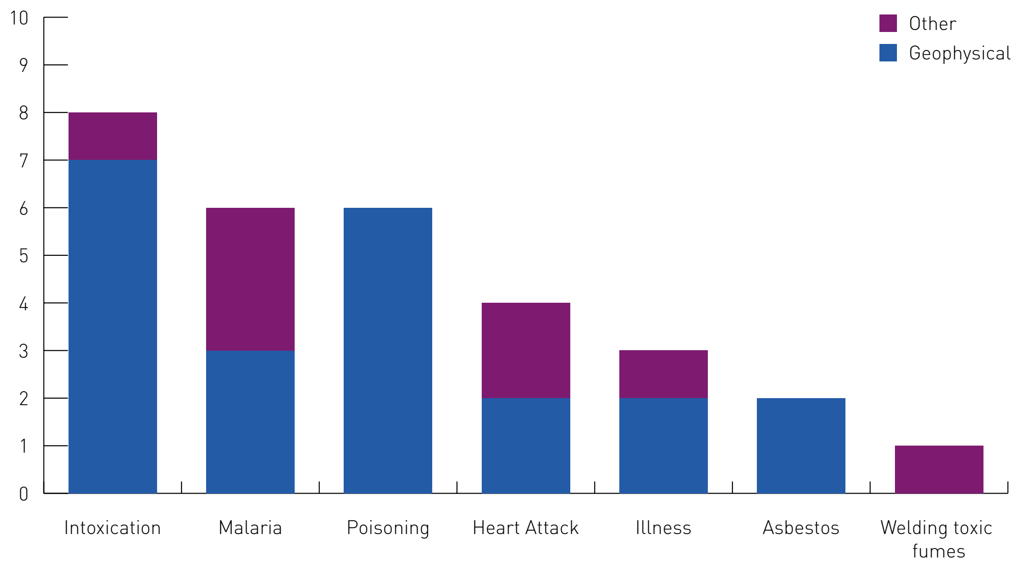

Figure 22: Medical, Geophysical and Other, Actuals and HiPo's.

Note that heart attacks are only reported in case they are related to the task performed, i.e. accidental rather than natural death.

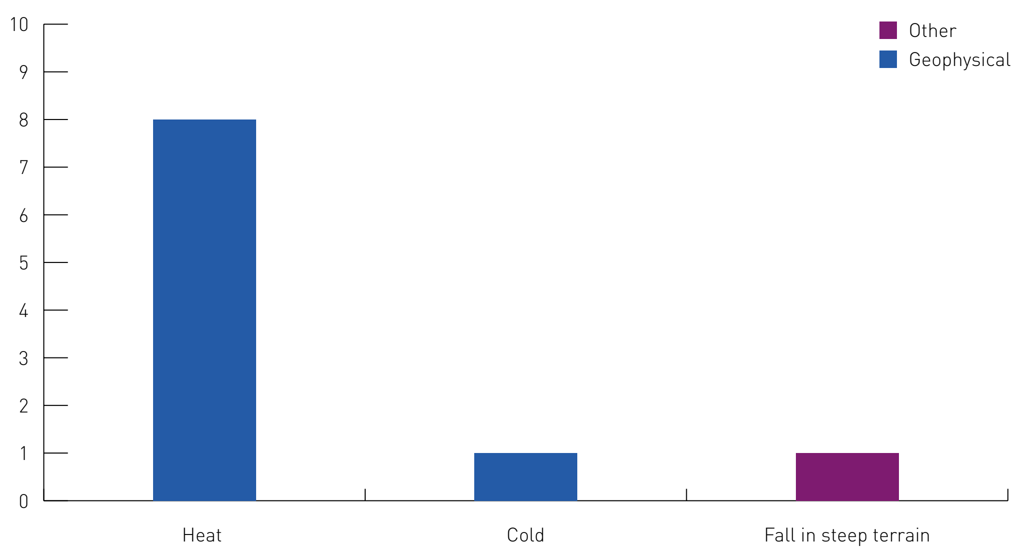

Figure 23: Temperature, Geophysical and Other, Actuals and HiPo's

The fall in steep terrain report was about a geologist who got disoriented due to heat and de-hydration and in this condition left the planned route and fell off a 40 m cliff.

Data Analysis: By Activity

The events in the Aide Memoir have also been classified along the activity in which they took place.

The below Figures 24 and 25 show the split by activity for Land and Marine.

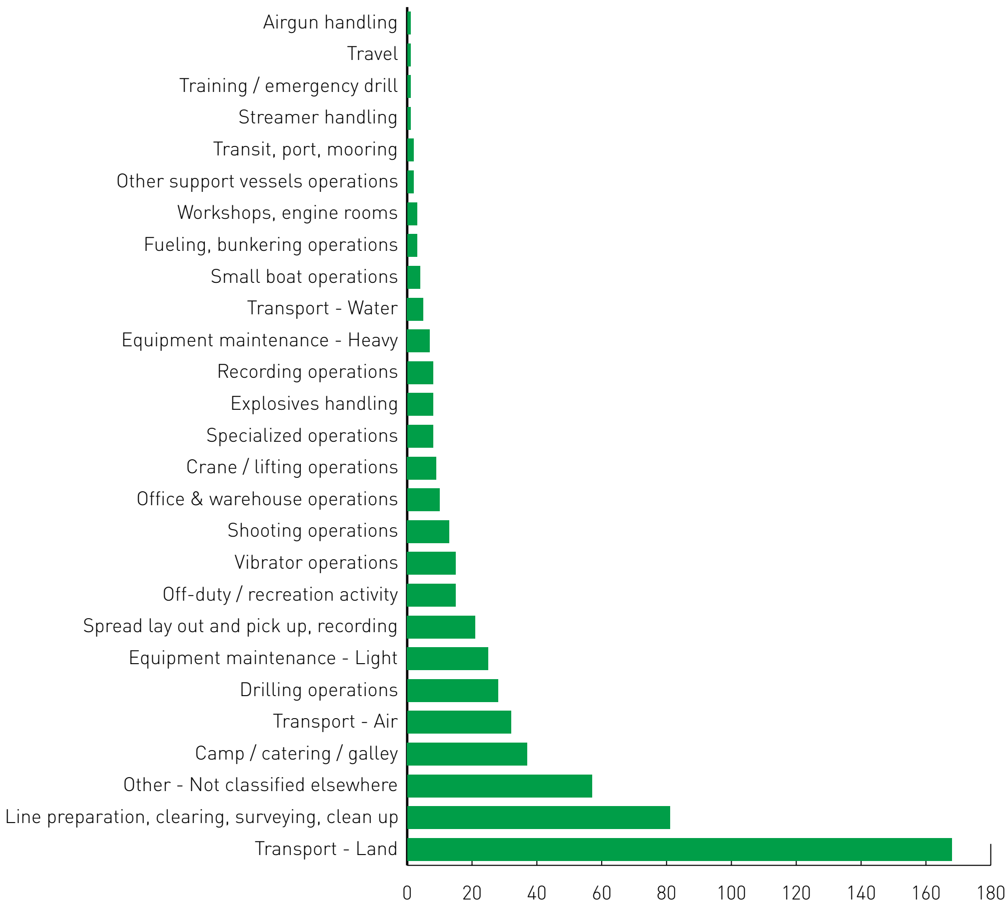

Figure 24: Incidents by type of activity, Land, Actuals and HiPo's

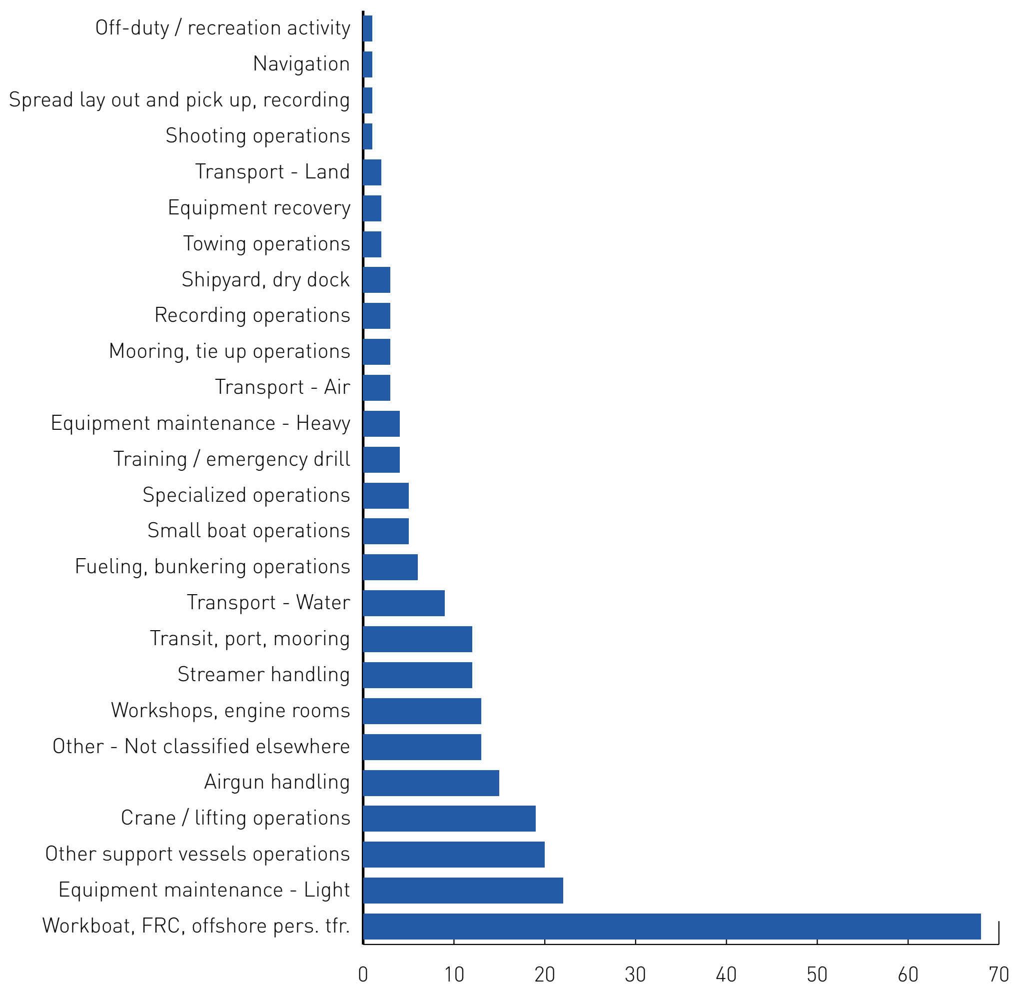

Figure 25: Incidents by type of activity, Marine, Actuals and HiPo's

Figure 26 shows finer classification for the activity 'Workboat, FRC and Offshore Personnel Transfer' in terms of numbers of events. Figure 27 shows the same but now in terms of actual number of fatalities. Note the predominance of Helicopter events!

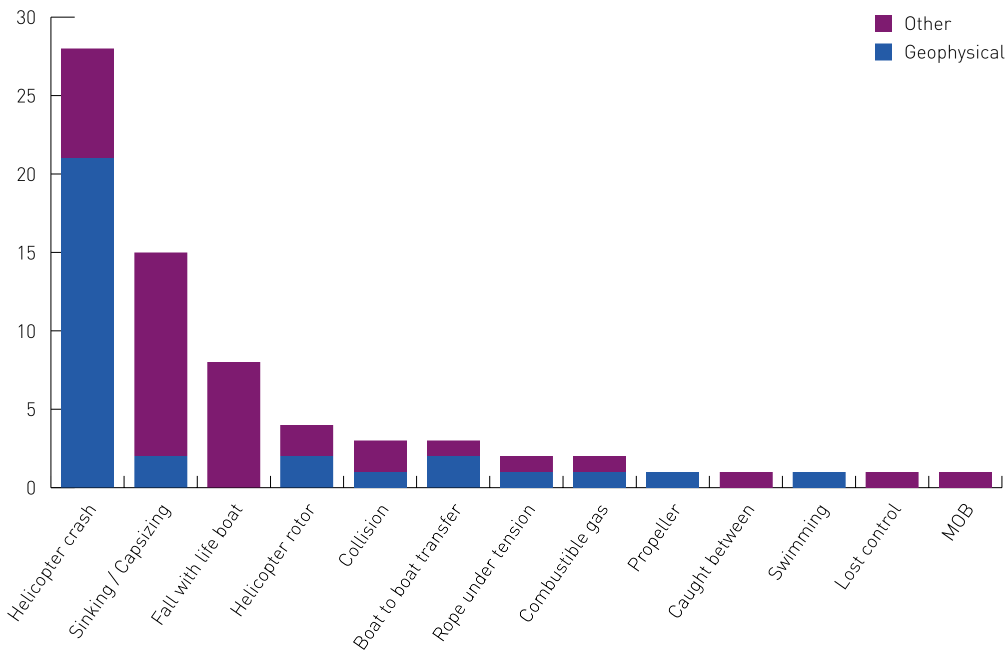

Figure 26: Activity: Workboat, FRC and Offshore Personnel Transfer, number of incidents Actual and HiPo's, Geophysical and Other

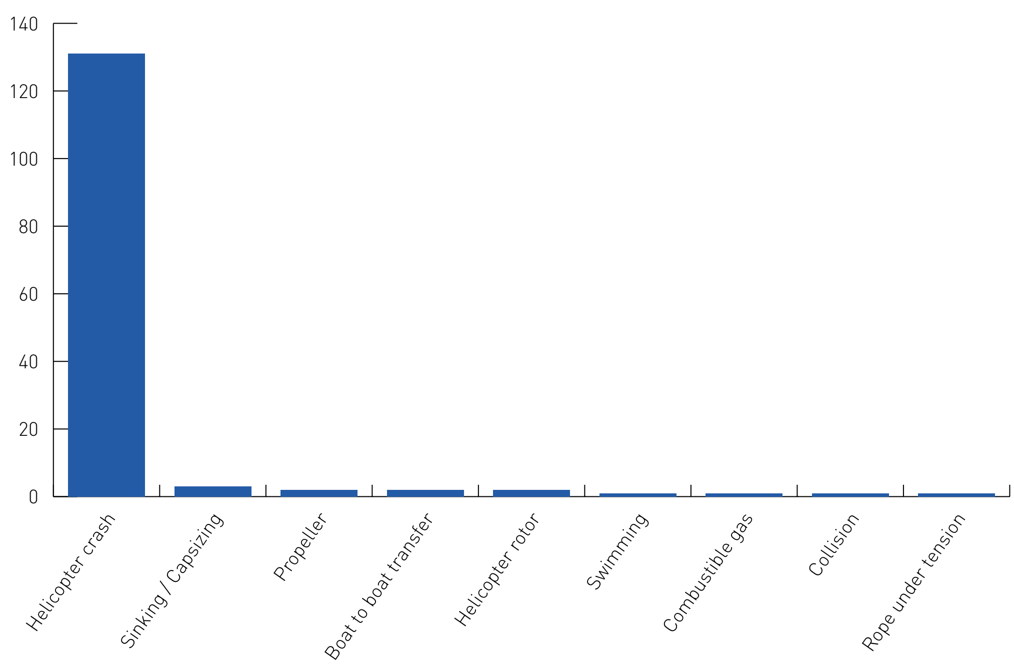

Figure 27: Same as above, but now the number of actual fatalities

Data Analysis: By Keyword

For each event, up to three keywords can be entered in the Aide Memoir database spreadsheet. This facilitates searching for specific events (e.g. events involving a knife). But statistical analysis of the occurrence of certain keywords also provides useful information, in particular in terms of how often an escalating factor was considered to have played a role. The graphs below show a selection of keywords, and the frequency with which they have been used. Note that some keywords may occur in more than one list.

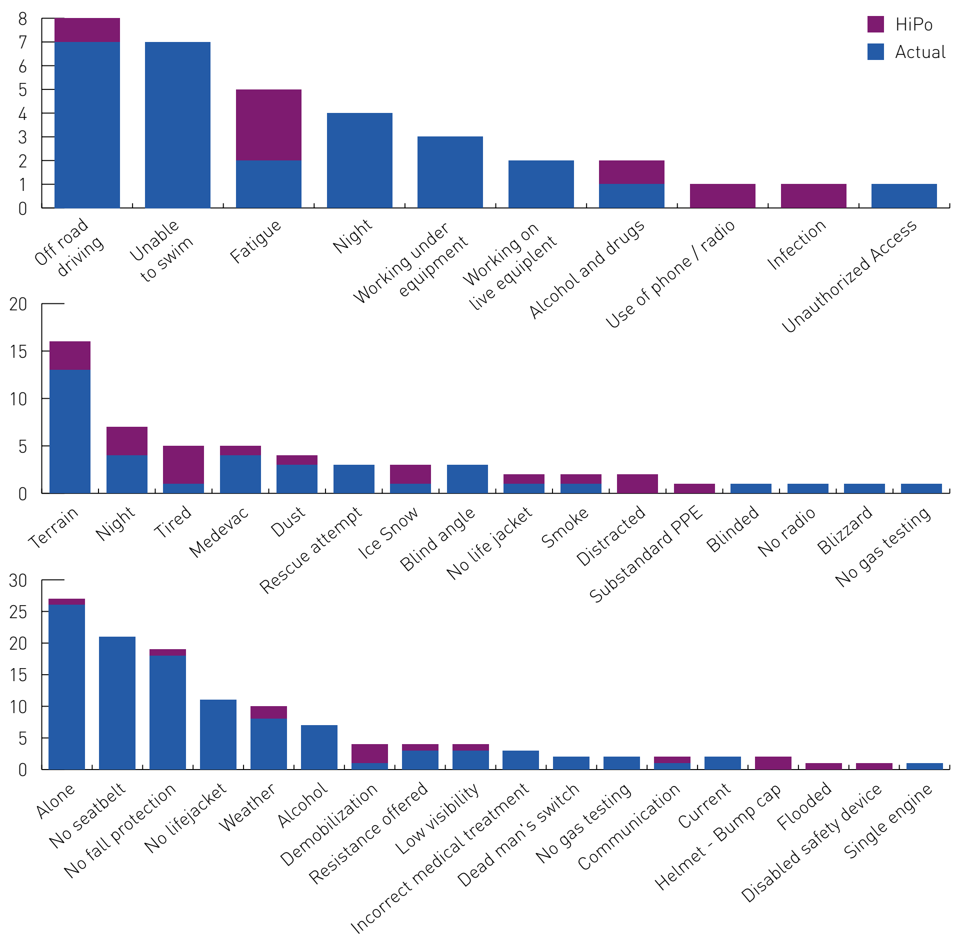

Figure 28: Number of events with specifically noted escalating factors (Keywords 1, 2, 3)

Prominent: Alone; Terrain; No: seatbelt/lifeline/lifejacket; fatigue/tired; night and alcohol (last three in two keyword lists).

Also note the number of fatal incidents during medevac, three of which were helicopter crashes at night!

Glossary

Below are terms defined for use in this document. The reader should also be aware of additional terms already defined in the Glossary sections in Reports 510, 423 and 432 for completeness.

Term	Definition
Activity Set	The activities which make up the sum-total of geophysical operations that results in specific, measurable outputs.
Activity Specific	A singular broad term which describes a phase of geophysical operations or a support activity to support geophysical operations, e.g. Project scouting; personnel logistics; line positioning and opening; equipment logistics; receiver and energy sources; recording, project remediation.
Barrier	A risk control that seeks to prevent unintended events from occurring or prevent escalation of events into incidents with harmful consequences.
Breakdown Event	The point where control is lost and there are consequences or potential consequences.
Consequence	A quantitative or qualitative measure of an adverse or beneficial outcome from an activity. The effect or potential effect of a Breakdown Event on People, Environment, Assets or Reputation (PEAR).
Consequence – Severity	The numeric value assigned to a consequence (used in the RAM).
Hazard	A source of potential harm or a situation with the potential to cause harm or loss.
Hazard – Dynamic	The hazards that are not task or activity based, for example weather, terrain, seasons, security.
Hazard – Static	The hazards that always exist for a specific geophysical task.
Hazard Register (not risk)	A document showing the activity and the tasks associated with the activity and the hazards associated with the task. Typically will be generated at the inception of the project before tendering.

Term	Definition
Hierarchy of Control	A set of measures which may modify the task, the hazard and the associated risk to a tolerable level. Usually the hierarchy is applied by considering the most effective measures down to least effective. The most effective measures modify the task. The least effective try to modify the consequences and therefore the severity.
Probability	The chance of a specific event or outcome measured by the ratio of specific events or outcomes to the total number of possible events or outcomes. Quantitative probability is expressed as a number between 0 and 1, with 0 indicating an impossible event, and 1 indicating the outcome is certain. For Geophysical Operations probability is described in Qualitative terms and is shown on the RAM in three categories General, Historical and Descriptive. This probability ranges from 'A' through 'E' with 'A' being 'Very Unlikely' to 'E' – Very Likely.
Recovery Measures	What will be done, after losing control, to ensure that the task is again under control.
Risk – Mitigation	Measures implemented to mitigate the consequences of a breakdown event.
Risk – Prevention	Measures implemented to control potential risks prior to a breakdown event.
Risk – Qualitative Assessment	A risk score derived from experiences or knowledge. A qualitative risk assessment is not based on rigorous numerical data.
Risk – Reassessment	An iterative process whereby a Risk Reassessment is conducted after mitigation or control measured are applied. This is done in order to evaluate any unexpected consequences from the actions taken.

Term	Definition
Risk Register	A document showing the activity and the tasks associated with the activity, the hazards associated with the task and the risk associated with the hazard. The risk register will show Dynamic, Crew based and Project specific hazards. Typically, the hazard register will describe the mitigation measures to be applied and contain a 'pre' and 'post' mitigation risk score.
Risk – Residual	The risk remaining after risk treatment or control measures have been applied.
Risk – Score	The product of Probability and Severity taken from the RAM, e.g. D3.
Risk – Tolerable	By definition, exposure to intolerable risk (as defined on each Company's RAM) has to cease until controls to reduce the level to tolerable are introduced.
Risk – Treatment	There are four options available – Tolerate, Treat, Transfer or Terminate.
Task(s)	A set of detailed processes for contributing to the activity which is being conducted.

Acronyms

The following acronyms are used in this document:

Acronym	Description
ALARP	As Low As Reasonably Practicable
AM	Aide Memoir
ATV	All-Terrain Vehicle
CAGC	Canadian Association of Geophysical Contractors
DROPS	DRopped Objects Prevention Scheme
E&P	Exploration and Production
FRC	Fast Rescue Craft
HiPo	High Potential (incident)
HRA	Health Risk Assessment
HSE	Health, Safety and Environment (but in this document also includes Security & Social Responsibility)
IAGC	International Association of Geophysical Contractors
IADC	International Association of Drilling Contractors
IMCA	International Marine Contractors Association
JSA	Job Safety Analysis
MOB	Man Over Board
MOC	Management Of Change
MOPO	Matrix of Permitted Operations
PPE	Personal Protective Equipment
PTW	Permit To Work
RAM	Risk Assessment Matrix
STEP Change	Step Change in Safety
TZ	Transition Zone
UXO	Un-eXploded Ordnance

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The geophysical industry has static hazards and risks that are inherent to its assets and operational activities. While most of the risk cannot be completely eliminated, it needs to be managed and controlled to a tolerable level of residual risk.

In this document, we will refer to a Hazard as anything which can cause harm or potential harm. Harm could be caused to people, to the environment, to the assets or equipment being used, or to the reputation of the company or the industry. Risk is the product of the potential consequence and the probability of an event occurring.